Phase 1 Validation Test Plan

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Group-2 Consortium

Group-2 Consortium (http://g2calibration.cmr.gov):

SAIC, University of Colorado, Harvard University, University of California at San Diego, Multi-max, and Geophysical Institute of Israel.

Sponsor: The Defense Threat Reduction Agency, Arms Control Technology Division, Nuclear Treaties Branch.

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Principle Investigator:

Dr. Keith McLaughlin, SAIC/CMR, 1300 N. 17th Street, Suite 1450, Arlington, VA 22209, (703) 247-4135, (703) 524-2073 (FAX), scatter@cmr.gov

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1. Scope

The purpose of this validation test plan is for the Group-2 Consortium members and DTRA CMR R&D Testbed personnel to keep clearly defined goals and schedules on the project development and to make an organized effort in completing the tasks and cooperation for Phase 1. It also intends to provide as much information as possible to the R&D Testbed for preparation of validation test of SSSCs. This plan follows “Phase 1 Data Delivery Plan” delivered to the R&D Testbed in November 2000. The “Phase 1 Data Delivery Plan” sketched out a schedule and estimated deliveries for Phase 1. We recognize that R&D Testbed may modify existing tests and design and/or apply different tests. Testing is expected to use Integration Testbed facilities of the R&D Testbed.

This validation test plan includes nine sections: Scope, Background, Delivery, R&D Testbed Installation, R&D Testbed Validation Tests, Schedule, Estimated Level of Effort, Resources Required, and References. Only brief descriptions are given for each of the deliverables. This plan serves as a starting point for the documentation effort. Corresponding Consortium members may begin to draft their reports which will contribute to the R&D Testbed delivery and the CCB proposal.

2. Background

The successful development of Source Specific Station Corrections (SSSCs) for Fennoscandian and North American IMS seismic stations have demonstrated that event locations and uncertainties can be improved by applying travel time corrections in event location. The SSSC approach used was to develop model-based corrections and then use Ground Truth (GT) data for validation testing. These SSSCs are applied to seismic event locations for calibration of the default IASPEI91 travel times used at the PIDC/IDC at regional distances.

The Group-2 Consortium carries out seismic location calibrations for IMS stations in North Africa, Middle East, and Western Asia using advanced methodology. Station corrections for IMS seismic stations in the region are developed to improve location accuracy and reduce error ellipses. We calculate SSSCs for Pn, Sn, Pg, and Lg phases out to 20 degrees for 32 primary and auxiliary IMS stations in North Africa, the Mediterranean, Middle East and West Asia (Figure 1). The work consists of two phases, preliminary and refined corrections, respectively. In the first phase we develop preliminary SSSCs, without slowness and azimuth corrections, for sources at 10 km depth to avoid the effects of low velocity sedimentary layers. In Phase 2 we will refine and improve the models and methods to obtain final station corrections, including depth sources. Model-based slowness-azimuth corrections will be developed and compared with the empirical ones. In both phases, validation testing will be conducted using GT events to demonstrate improvement on event locations when using the corrections. This validation test plan describes development and testing for Phase 1.

In this work we develop regional models by compiling 1D velocity models and regionalizations for the region. 3D hybrid models are developed by combining the regional models with global ones. SSSCs are calculated using 3D ray tracing. Event clusters are selected and Joint Hypocenter

Determination (JHD) and Hypocenter Decomposition (HDC) are used to obtain empirical travel time corrections for small regions. Cross comparison of methodologies contributes to a-priori modeling error estimates. Validation testing of the model-based SSSCs is conducted by relocating ground truth (GT0-GT5) events. They are recorded at IMS stations and/or surrogate stations (Figure 2) as well as other stations (Figure 3), and distributed throughout the study region. We evaluate reductions in mis-locations and error ellipses by applying SSSCs in event location.

Reference events and candidate GT events are collected for model validation test and IMS location improvement test. They are maintained in an Oracle database, called *GROUP2DB*, at the CMR (Group-2 Consortium, 2001). Bulletins are available at the consortium web site *http://g2calibration.cmr.gov.*

3. Delivery

The Group 2 Consortium Phase 1 Delivery consists of the following:

- Reference Event Database for events in the region of Mediterranean, North Africa, Middle East and Western Eurasia.
- SSSCs/modeling errors and supporting files for Pn, Pg, Sn, Lg from 0 to 20 degrees at the IMS stations, surrogate and other stations in the study region (Figures 1-3).
- Validation Test Database for offline validation tests, which includes selected events from the Reference Event Database.
- Validation test scripts for conducting offline tests within the R&D Testbed.
- 3D Models used to construct the SSSCs.
- Documentation on the models, reference events, and validation tests conducted by Group-2 Consortium.

An estimate of these deliverables has already been provided in the “Phase 1 Data Delivery Plan”.

3.1 Reference Event Database

3.1.1 Description

The validation testing for regional SSSCs in Group-2 Consortium region of interest is conducted using GT events to verify event location improvement relative to GT and location error ellipse coverage. Since the expected improvement in location is on the order of 10 km, the location of reference events should preferably be within 5 km accuracy or better. We mainly focus on GT0-GT5 events for relocation and error ellipse validation, but GT10 events are also used for validation testing for better coverage of the region with larger data sets. All events used in validation testing are not used in the model development.

In collecting data, the consortium has developed criteria for candidate GT5 reference events, i.e. events meeting the requirements are probably located better than 5 km:

- 10 or more stations at distance < 250 km

- 10 or more time-defining phases within 250 km
- Minimum distance of recording stations <= 30 km
- Largest azimuthal gap < 120 degrees at stations within 250 km

and desirably:

- Magnitude mb > 3.5
- Depth <= 35 km
- Phases recorded at IMS stations or surrogates
- First arrivals recorded beyond 250 km
- Semi-major axis of error ellipse <= 5 km
- Event located using a local velocity model

Reference events are validated using cluster analyses if the event locations are obtained from seismic networks.

The Group-2 Consortium Reference Event Database mainly consists of GT0-GT5 events in our study region obtained by consortium members as well as from the CMR Ground Truth Database (Yang et al., CMR-00/15, 2000; Group-2 Consortium, 2001). As of February 2001, 837 events are in the database, and 589 of them have arrival data (Figure 4). Candidate events for GT5 or better are also collected based on reference event selection criteria above.

Reference events include nuclear explosions, chemical explosions (e.g. identified with the size of the mine or quarry less than 5 km), and well-located earthquakes. Data are collected from the PIDC REB, NEIC and ISC bulletins as well as national and local network bulletins in the region. Arrival data include phases recorded at IMS stations (Figure 1), or their surrogate stations (Figure 2), as well as other stations in the region (Figure 3). GT0-GT5 events with arrival data are used in major SSSC validation tests. Arrivals may be from IMS stations and/or other seismic stations. Surrogate stations may be used at the absence of IMS stations since testing and validating the models are irrelevant which stations recorded the event.

Both JHD and HDC are used to derive path-dependent corrections from event clusters, recorded by IMS stations, their surrogates and other teleseismic/regional stations. Comparison are made between these empirical corrections and model-based SSSCs for cross validation. Station corrections and statistical scatter of clusters are used as one source of information in estimating modeling errors.

The Phase 1 Reference Event Database will be finalized by the time of delivery. This delivery may consist of up to 4000 events. The deliverables include parametric data, e.g. associated arrival and stations. The database will be described in accompanying technical reports, including Reference Event Database Report, Cluster Analysis Report, and Reference Event Database Schema Report.

3.1.2 Requirements

The data will be provided as an Oracle export dump. Procedures for installing the Oracle dump are given in Section 4.

Estimated Oracle table space is 1 GB for tables and indexes. Estimated temporary disk space is 1 GB for the Oracle export dump. This disk space can be freed after the database is imported.

3.2 SSSCs and Modeling Errors

3.2.1 Description

Regional SSSCs are defined on rectangular latitude/longitude grids where both a travel-time correction and a modeling error are assigned to each grid point. The corrections are given relative to the default IASPEI91 travel times. Grid spacing is chosen as one degree for both latitude and longitude. SSSC modeling errors are estimated at each grid point, i.e. the uncertainty in the predicted travel times, to ensure 90% ellipse coverage. Regional SSSCs are computed for Pn, Sn, Pg, and Lg phases out to 20 degrees for IMS stations, and surrogate/other stations when necessary, in the study region. A 3D ray tracing program is used with the 3D hybrid models as input. Modeling errors are obtained from the scatter of travel times caused by small perturbations in the model parameters and from the comparison of travel times obtained by different ray tracing algorithms and empirical JHD/HDC station corrections.

Description on the SSSC development will be included in the reports to accompany the delivery (Regional SSSC Development Report, 3D Ray Tracing Development Report, and Model Error Estimate Report). All reports will be appendices to the CCB proposal.

3.2.2 Requirements

Disk space estimates are <500 MB. We expect to provide between 200-1000 station SSSCs for validation testing. Procedures for installing the SSSCs are given in Section 4.

3.3 Validation Test Database

3.3.1 Description

Group-2 Validation Test Database includes data sets and test results from the offline validation testing (See Section 5). These tests are conducted to validate the model and IMS location improvement. Detailed descriptions are provided in the "Group-2 Consortium Validation Test Report". The tests will be repeated on the R&D Testbed. Results will be documented in an "R&D Testbed Validation Test Report". Both reports will be appendices to the CCB proposal.

3.3.2 Requirements

The data will be provided as an Oracle export dump. Procedures for installing the Oracle dump are given in Section 4.

Estimated Oracle table space is 1 GB. Estimated temporary disk space is 1 GB for the Oracle export dump. This disk space can be freed after the database is imported.

3.4 Test Scripts

3.4.1 Description

Test scripts will be documented in the “Test Check List” to accompany the data delivery. Procedures for installing and running scripts will be provided as part of the “Test Check List”.

3.4.2 Requirements

Scripts are written in Perl, and require database read and write access. More detailed anticipated requirements are listed in Section 5 for each individual test.

3.5 Models

3.5.1 Description

Models used in SSSC calculations are provided in the delivery. They will be documented in accompanying reports (Model Development Reports). Two 3D hybrid models are used to construct SSSCs.

1. UCB Model 1.x

University of Colorado at Boulder constructs a 3D hybrid model by combining global mantle models with global crust and upper mantle models using improved group and phase velocity data sets and inversion methodology. The development of this model is documented in the “Model Development Report: UCB Model 1.x”.

2. SAIC regionalized model 1.x

The study region, a coordinate rectangle (15S,40W)-(80N,100E), is divided into a number of regions and a velocity model is assigned to each region (Figure 5). This work is mostly based on literature search results. A hybrid 3D model is obtained by combining this crustal model with the Harvard models P362 and S362. The Harvard model is a new joint, P and S velocity model of the mantle parameterized in terms of radial and horizontal cubic splines, using a combination of direct and differential travel times and surface wave phase measurements. The construction of this model is documented in the “Model Development Report: SAIC Model 1.x”.

3.5.2 Requirements

The estimated disk space is 1 GB. Estimated Oracle table space is 100 MB (already included in the requirement in Section 3.1).

3.6 Documentation

3.6.1 Description

Several reports will be provided to document Model Development Reports, Model Error Estimation Report, SSSC Development Report, Reference Event Report, Cluster Analysis Report, Database Schema Report, and Validation Test Reports. All reports will appear as appendices to the CCB proposal.

3.6.2 Requirements

All documenting reports will be provided in PDF format. Total document disk space is estimated as 100 MB.

4. R&D Testbed Installation

4.1 Delivery inventory

All files are transmitted from the Group-2 Consortium to the R&D Testbed using a tape for clarity. It contains two tar files of Oracle export dumps of databases and log files, a tar file of the SSSCs and modeling errors, a tar file for par files used in validation testing, a tar file of the test scripts, a tar file of the models, and a tar file of documentations. Each of the delivery components is described in Section 3. A ”Test Check List” will also be delivered on the tape to include an inventory of the delivered files and describe additional details on how to install and use the files.

4.2. Pre-installation preparations

Disk and database related preparations are needed before installing the Group-2 Consortium delivery.

4.2.1 Disk space

It requires about 4 GB disk space to unpack the delivered tape.

4.2.2 Oracle tablespace

The total size for both tables and indexes in the delivery is estimated as about 2 GB.

4.2.3 Database accounts

A user account for validation testing should be created on the Integration Testbed main database system using the same names as the Group-2 Consortium’s, i.e.*G2TEST.*

A user account for Group-2 Reference Event Database should also be created. It may not reside on the main database system since it will not be directly used in the R&D Testbed validation testing.

4.3. Installation instructions

We recommend the following steps when installing the delivery: import databases, unpack tar files of SSSC files, par files, scripts, models, and documentations. The order of execution is arbitrary.

4.3.1 Import the Reference Event Database

To unpack the database tar file, type:

tar -xf refdb.tar

This results in two files:

- Reference event database files: group2db.dmp, group2db.log

To import the database, type:

imp $database/$password@$db full=y buffer=200000 commit=y

These load in a suite of database tables for the Group-2 Reference Event Database. This database is not directly involved in validation test. The tables contain GT data, station information, metadata, and velocity models:

1. Database tables for GT data

- ORIGIN: origin table for event origin time and location
- ASSOC: assoc table for phase name and defining flag
- ARRIVAL: arrival table for phase picks
- ORIGERR: origerr table for origin errors. Only used in evaluation.
- EVENT: event table for preferred origin information
- ORIGAUX: origaux table for data quality information
- AMPLITUDE: amplitude table for amplitude, period, etc.
- NETMAG: netmag table for event magnitude
- STAMAG: stamag table for station magnitude.
- REMARK: remark table for remarks on data.

2. Database tables for station information

- SITE: site table for station coordinates
- AFFILIATION: affiliation table for network

3. Database tables for Metadata

- BIBLIOGRAPHY: bibliography list used for constructing the regionalized model

- ORIGINTAG: origintag table for origin-based data source information.
- REFERENCE: reference table for data sources.
- METADATA: metadata table for online storage of data sources.
- CONTACT: contact table for information on the contact person who has provided data

4. Database tables that contains the models used in SSSC calculations.

- VGRID: vgrid table contains geographic grid files from regionalization.
- VLAYER: vlayer table contains data on velocity, density, attenuation, etc.
- VMODEL: vmodel table contains data on a velocity model
- VREGION: vregion table contains regionalization polygons

4.3.2 Import the Validation Test Database

To unpack the database tar file, type:

tar -xf testingdb.tar

This results in two files:

- Validation test database files: g2test.dmp, and g2test.log

To import the database, type:

imp g2test/$password@$db full=y buffer=200000 commit=y

These load in a suite of database tables for the Validation Test Database. This database is directly used in validation testing. It includes data selected from the Reference Event Database. The tables contain GT data to be used in validation testing, associated station information, and Group-2 validation test results:

1. Database tables for GT data involved in the validation testing and evaluation:

- ORIGIN: origin table for event origin time and location
- ASSOC: assoc table for phase name and defining flag
- ARRIVAL: arrival table for phase picks
- ORIGERR: origerr table for origin errors. Only used in evaluation.

2. Database tables for station information

- SITE: site table for station coordinates
- AFFILIATION: affiliation table for network

3. Database tables for outputs from Group-2 Consortium validation testing

- ORIGIN_W: output origin table for test results when SSSCs are applied

- ORIGERR_W: output origerr table for test results when SSSCs are applied
- ASSOC_W: output assoc table for test results when SSSCs are applied
- AR_INFO_W: output ar_info_table table for test results when SSSCs are applied
- ORIGIN_WO: output origin table for test results when SSSCs are not applied
- ORIGERR_WO: output origerr table for test results when SSSCs are not applied
- ASSOC_WO: output assoc table for test results when SSSCs are not applied
- AR_INFO_WO: output ar_info_table table for test results when SSSCs are not applied

4.3.3 Unpack tar files: SSSC.tar

tar -xf SSSC.tar

This unpacks the input files for validation testing, including the SSSCs files, *TT.$sta.$phase.reg.group2*, and a par file, *ars.par.* These files need to be installed in the Testbed system before validation testing is conducted (See Section 4.5).

4.3.4 Unpack tar files: Par.tar

tar -xf Par.tar

This unpacks the par files used in validation testing, including:

- EVLOC_W.PAR: EvLoc par file for event location with SSSCs
- EVLOC_WO.PAR: EvLoc par file for event location without SSSCs

4.3.5 Unpack tar files: Script.tar

tar -xf Script.tar

This unpacks the scripts used for validation testing. More details are given in the “Test Check List” accompany the delivery.

4.3.6 Unpack tar files: Model.tar

tar -xf Model.tar

This unpacks the models used for SSSC calculations. These files are not directly used in validation testing.

4.3.7 Unpack tar files: Doc.tar

tar -xf Doc.tar

This unpacks the documentations accompany the delivery, including:

- Group-2 Consortium Model Development Report: UCB Model 1.x

- Group-2 Consortium Model Development Report: SAIC Model 1.x
- Group-2 Consortium Model Error Estimation Report
- Group-2 Consortium Regional SSSC Development Report
- Group-2 Consortium Cluster Analysis Report
- Group-2 Consortium Reference Event Database Report
- Group-2 Consortium Reference Event Database Schema Report
- Group-2 Consortium Validation Test Report

4.4 Post-installation recommendations

We recommend that all user privileges other than “select” be revoked for the database tables delivered by Group-2 Consortium.

4.5 Pre-testing preparations

4.5.1 Software baseline

The R&D Testbed system should be configured to be at the same PIDC7 patch level as Operations. Directly involved program/files in the validation tests include EvLoc, SASCs, and SSSCs for Fennoscandian stations.

4.5.2 SSSCs and par files

To install the SSSC files for validation testing,

- Copy the SSSC files *TT.$sta.$phase.reg.group2* to directory *$(STATICDIR)/TT/iasp91/SSSC*
- Copy the station definition file *ars.defs* to directory *$(STATICDIR)/TT/vmsf* to replace the existing one

where $(*STATICDIR*) is */cmss/config/earth_specs*.

4.5.3 Database tables

For validation test, in the *G2TEST@$db*, create empty tables with indexes for outputs from validation test in the validation test database:

- RND_ORIGIN_W: output origin table for test results when SSSCs are applied
- RND_ORIGERR_W: output origerr table for test results when SSSCs are applied
- RND_ASSOC_W: output assoc table for test results when SSSCs are applied
- RND_AR_INFO_W: output ar_info_table table for test results when SSSCs are applied
- RND_ORIGIN_WO: output origin table for test results when SSSCs are not applied
- RND_ORIGERR_WO: output origerr table for test results when SSSCs are not applied

- RND_ASSOC_WO: output assoc table for test results when SSSCs are not applied

The table size is no smaller than that of the delivered tables (Section 4.3.2).

4.5.4 Other data set

For GA testing, a synthetic data set (Bondár, 2001) needs to be installed in the validation test database. To install, copy the following tables from account *rddb1@pumpkin*:

- SYN_ORIGIN: origin table for synthetic event origin time and location
- SYN_ASSOC: assoc table for synthetic phase name and defining flag
- SYN_ARRIVAL: arrival table for synthetic arrivals
- SYN_AMPLITUDE: amplitude table for synthetic amplitude, period, etc.

4.6 Installation checks

Installation and preparation checks validate that databases and files have been installed correctly, and validation testing can be technically conducted on the R&D Testbed.

4.6.1. Database check

1. Objective

The objective is to validate correct installation of Oracle relational database tables of the Group 2 Reference Event Database and Validation Test Database.

2. Requirements

The test requires read-access to the Reference Event Database and the test database installed.

3. Procedure

Check import logs against the export log files delivered.

4. Metrics

To be provided in the “Test Check List”.

5. Pass/Fail Criteria

Installation is considered as failed if the comparisons yield differences between the original and the installed versions.

4.6.2 File check

1. Objective

The objective is to validate correct installation of SSSCs and related files and correct PIDC7 configuration.

2. Requirements

The test requires read-access to the directories/files in the Integration Testbed configuration tree.

3. Procedure

Compare names and sizes of directories/files with the "Test Check List" included in the delivery for installation test, and with the Integration Testbed configuration.

4. Metrics

To be provided in the “Test Check List”.

5. Pass/Fail Criteria

Installation/configuration is considered as failed if the comparisons yield differences between the original and the installed versions.

5. R&D Testbed Validation Tests

Relocation & integration comparison tests of SSSCs will be conducted on the CMR R&D Testbed. The tests have three major objectives: (1) Validate the models developed for SSSC computations; (2) Validate the offline relocation improvements using the SSSCs with respect to locations without the SSSCs using GT events; (3) Test the impact of SSSCs on GA and ARS to ensure that the SSSCs do not have negative impact on the PIDC/IDC location processing.

We expect only minimal effort is needed for the testing since:

- The offline model validation test using well distributed GT0-GT5 events in the study region will have been done prior to the delivery (Validation Test Report). Further, in a separate test models have been validated by comparing the SSSCs with empirical corrections derived from JHD/HDC cluster analyses (Cluster Analysis Report).
- Offline validation tests will test, when using the SSSCs, location biases will be significantly reduced, and confidence ellipses will be reduced without significant reduction in confidence ellipse coverage prior to the delivery (Validation Test Report).
- The successful use of current SSSCs in ARS for Fennoscandian and North American IMS stations shows that SSSCs do not impact ARS interactive processing.
- Previous testing showed that added automatic processing (GA) computational burden will not overshadow expected benefits of SSSCs (Bondár, CCB, 2001).

5.1 Test 1: Validation Offline Relocation Test

Validation offline tests include model validation testing and IMS location improvement testing conducted by relocating events using EvLoc. For model validation, some representative GT0-GT5 events across the study region are selected, and a selected arrival data are used, including IMS, surrogate, and other stations. For IMS location testing three data sets are used to validate the regional SSSCs. The first data set (few hundreds of events) includes GT0-5 events to validate regional SSSCs for IMS and/or surrogate stations. The second data set (less than one hundred events) includes GT10 Mid-Ocean Ridge and Transform (MORT) events to validate regional and teleseismic SSSCs using the geological features as GT information. The third data set (thousands of events) includes candidate GT5 EHB events to validate the regional SSSCs.

The events in the validation test data sets are all unrelated to the data used in deriving the velocity models. Evaluation metrics will measure the improvements in location, uncertainties and coverage when corrections are applied with respect to default travel time tables. These tests are the repeats of tests done by the Group-2 Consortium (Validation Test Report).

5.1.1 Test 1a: Model Validation Test Using A Large Set of Stations

1. Objective

The objective of this test is to validate the models and model errors in the study region. Events used in relocation are selected GT0-GT5 events which best cover the region, instead of being driven by seismicity or data density in the Consortium database. For events with good azimuthal coverages and nearest distances, only randomly selected arrivals, instead of all arrivals, are used in event relocation. This is done to reveal the effectiveness of SSSCs, since velocity models/travel times are less important in these cases. SSSCs for IMS stations, surrogates, as well as other stations are all calculated and used in event relocation as needed.

2. Requirements

The test requires running the EvLoc program, read and write-access to the Validation Test Database *G2TEST,* correct installation of SSSC and station files, and correct configuration of PIDC7 baseline software (see Section 4.5).

3. Procedure

Par files are provided for running EvLoc, which specify input and output database tables and SSSCs to be applied. Scripts will be provided to compare test results with and without SSSCs.

4. Metrics

Detailed evaluation will be conducted for a number of categories, including:

- Distance from GT for all data, and as a function of ndef
- Area of error ellipse area
- 90% error ellipse coverage

- Origin time difference from GT
- Origin time error
- Standard deviation of observations
- Time residual, defining phases
- Time residual, all phases

A sample set of metrics is given in Appendix 1. For Phase 2 detailed depth evaluation will be included in the metrics. The final set of detailed metrics will be provided as part of the script and "Test Check List" delivery.

5. Pass/Fail Criteria

Event location should be improved and/or error ellipses reduced without loss of coverage for most of events when SSSCs are applied.

5.1.2 Test 1b: IMS Location Improvement Validation Test Using GT0-GT5 Events

1. Objective

The objective of this test is to validate the IMS location improvement in the study region when using regional SSSCs. GT0-GT5 events in the study region are used in event relocation. SSSCs are calculated for only IMS stations and surrogates for regional phases.

Three categories of tests will be conducted:

(1) Calibrated regional, uncalibrated regional, and teleseismic: with and without regional SSSCs, and all other defining phases are used in event relocation;

(2) Calibrated regional, and teleseismic: with and without regional SSSCs, and only teleseismic defining phases are used in event relocation;

(3) Calibrated regional only: with and without regional SSSCs, and no other defining phases are used in event relocation.

The first test will be able to utilize all events in the GT0-GT5 data set, but location improvement with SSSCs may not be significant, compared to that without SSSCs, due to good azimuthal coverage and nearest stations. The second test will only be able to use a subset of the GT0-GT5 events since some events may not relocate without regional phases other than IMS and surrogate stations. The result should reveal more significant location improvement when regional SSSCs are applied. The third test will be limited. It will not test reality where teleseismic phases are actually used in event location, but it will separate the effect of regional SSSCs from the contribution of teleseismic phases to event location.

2. Requirements

Requirements are identical to Test 1a.

3. Procedure

Procedures are identical to Test 1a.

4. Metrics

The same metrics will be applied as in Test 1a.

5. Pass/Fail Criteria

Evaluation metrics will be examined for improvement using SSSCs in event location. Major metrics include:

- The median mislocation of GT events should be significantly reduced
- Mislocation should be reduced by 20% or more for the majority of the events
- Median area of confidence ellipses should be reduced in area, and the coverage (percentage of GT events lying within the confidence ellipse) should be the same or better
- Confidence ellipses should be reduced by 20% or more for the majority of the events
- Fit, as expressed by residuals or their variance, should be similar or better

Additional metrics will be developed to measure the performance of the SSSCs (e.g. ellipse coverage consistent with the confidence level).

5.1.3 Test 1c: MORT GT10 Events

1. Objective

The objective of this test is to validate the regional SSSCs. At least 35 GT10 MORT events in the study region will be relocated. Comparisons are made relative to the geological features for relocation results with and without SSSCs. We expect that GT10 events will be adequate to test SSSCs at MORT's.

2. Requirements

Requirements are identical to Test 1a.

3. Procedure

Procedures are identical to Test 1a.

4. Metrics

The same metrics will be applied as in Test 1a.

5. Pass/Fail Criteria

Event location should be improved without loss of coverage when SSSCs are applied.

5.1.4 Test 1d: EHB Candidate GT5 Events

1. Objective

The objective of this test is to validate the regional SSSCs using a larger data set that Test 1b. These events may be GT5, or at least GT10. This test differs from Test 1b in that we do not expect the events to be of sufficient accuracy that strict statistical test will have enough power to make a definitive pass/fail criteria.

The candidate GT5 EHB events in the study region will be relocated. Only IMS and surrogate stations are used to test SSSC's effectiveness by avoiding good azimuthal coverage and nearest distances. Comparisons are made for relocation results with and without SSSCs. While the location improvement using SSSCs may be ambiguous due to the uncertainties in the locations of the candidate events, the SSSC performance serves as a bottom line check in which SSSCs should not degrade event location performance.

2. Requirements

Requirements are identical to Test 1a.

3. Procedure

Procedures are identical to Test 1a.

4. Metrics

The same metrics will be applied as in Test 1a.

5. Pass/Fail Criteria

Overall event location should be improved when SSSCs are applied. This test is largely a "do no harm" test.

5.1.5 Test 1e: TBD

TBD

5.2 Test 2: Impact on GA automatic system

Tests will be conducted using GA for two data sets:

- Synthetic data used in the previous GA testing
- Real time data for three data days

5.2.1 Test 2a: Synthetic data

1. Objective

The objective of this test is to ensure the automatic system can integrate the SSSC files without problems. This test is similar to a previous study (Bondár, 2001) except that here the real SSSC files are used.

2. Requirements

Requirements are identical to Test 1a, except that the synthetic data set needs to be installed and accessed in this test (see Section 4.5).

3. Procedure

Procedures are identical to Test 1a.

4. Metrics

Metrics include run time estimates and numbers of events formed by GA with and without SSSCs. The final set of detailed metrics will be provided as part of the script and "Test Check List" delivery.

5. Pass/Fail Criteria

GA should not crash. SSSCs should not cause significant delays in execution time.

5.2.2 Test 2b: Real time data

1. Objective

The objective of this test is to ensure the use of SSSCs do not cause problems in automatic event location processing (GA).

2. Requirements

Requirements are identical to Test 1a, except that real time data needs to be accessed in this test.

3. Procedure

Procedures are identical to Test 1a.

4. Metrics

The same metrics will be applied as in Test 2a.

5. Pass/Fail Criteria

The same criteria will be applied as in Test 2a.

5.3 Test 3: Impact on ARS interactive system

Tests will also be conducted using ARS for selected events in the GA testing data days. The analyst reviewed results will be compared with the automatic bulletins.

1. Objective

The objective of this test is to ensure the SSSCs will not cause problems in the interactive analyst event review process.

2. Requirements

Requirements are identical to Test 2b.

3. Procedure

Procedures are identical to Test 1a.

4. Metrics

The same metrics will be applied as in Test 2a.

5. Pass/Fail Criteria

The same criteria will be applied as in Test 2a.

6. Schedule

Delivery to the CMR R&D Testbed will occur in June 2001. Installation and testing may begin immediately.

If integration testing does proceed as planned, a second phase of integration testing is planned 1 month after the initial integration testing to allow for debugging and re-configuration depending upon available CMR resources.

A final “Test Report” will be jointly written by the R&D Testbed and Group 2 calibration personnel.

- June: installation and initial testing
- July: completion of testing
- August: draft the R&D Validation Test Report
- September: completion of the report; draft the CCB proposal
- October: further testing as needed
- November: submit the CCB proposal

7. Estimated Level of Effort

7.1 Personnel Provided by Group 2 Consortium

Scientist (Yang, Bondár, McLaughlin, Bhattacharyya, Israelsson) - 3 - 6 man-months

7.2 Personnel Provided by CMR R&D Testbed

- Scientist (Woodward, North, Bahavar...) - 1 - 2 man-weeks
- DBA - 1 to 8 man-hours
- Testbed Operator - 2 to 6 man-weeks (time spent operating the Testbed, not all of this time is specific to the testing described here)
- Analyst - 1 - 3 man-days

8. Resources Required

Resources required, given in previous sections, are summarized, including disk space, Oracle table space, Testbed configurations.

- Disk space: 3-6 GB
- Oracle space: 2-3 GB
- Testbed configurations: PIDC7 baseline and installations of Group-2 delivery

9. References

Bondár, I., GA testing, CCB Memo, 2001.

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Group-2 Consortium, Group-2 Consortium model development report: UCB model 1.x, 2001.

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Yang, X., I. Bondár, and C. Romney, PIDC Ground Truth Event (GT) Database (Revision 1), CMR Technical Report CMR-00/15, 2000.

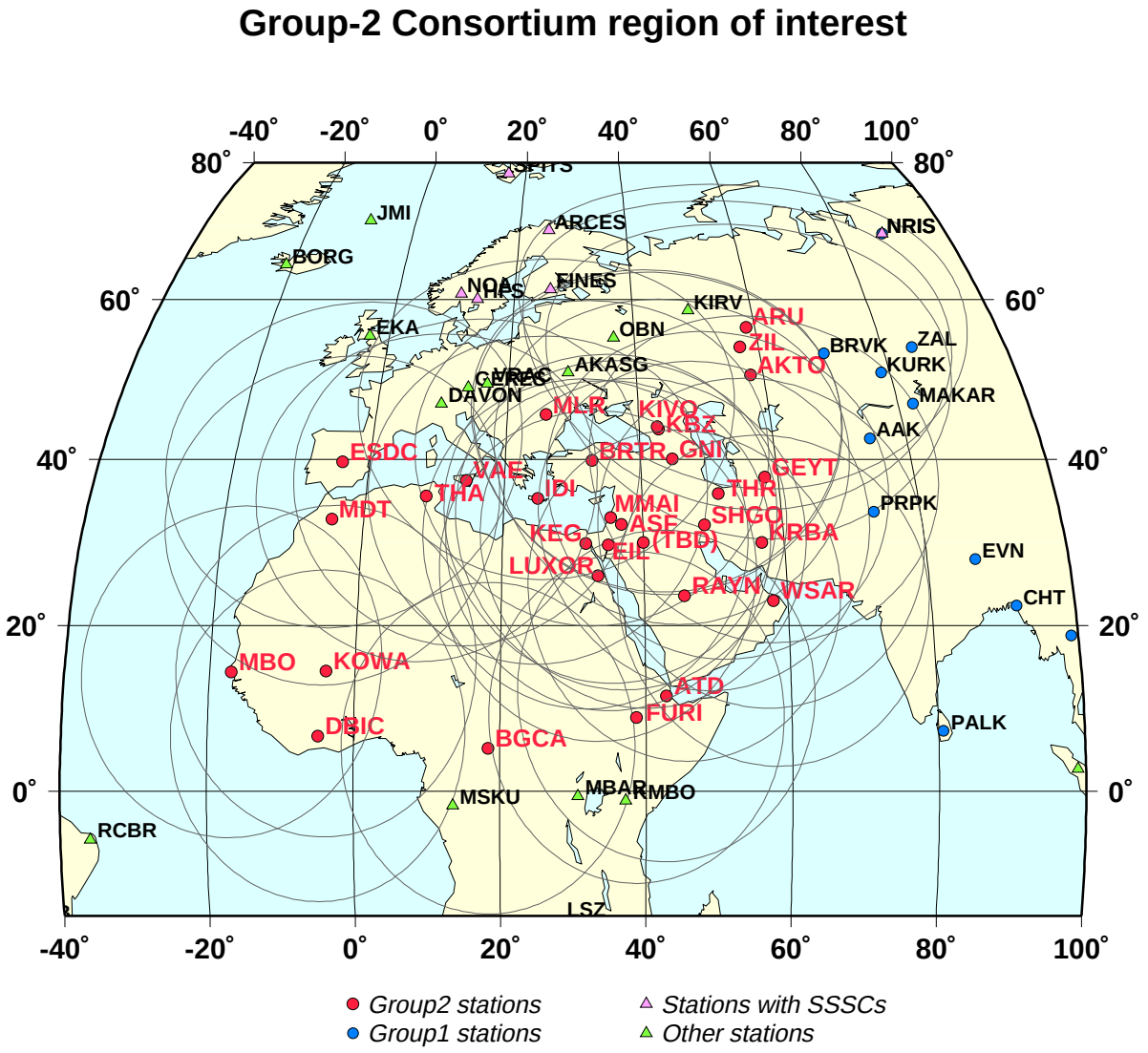

Figure 1. Group-2 consortium region of interest, including 32 IMS primary and auxiliary stations.

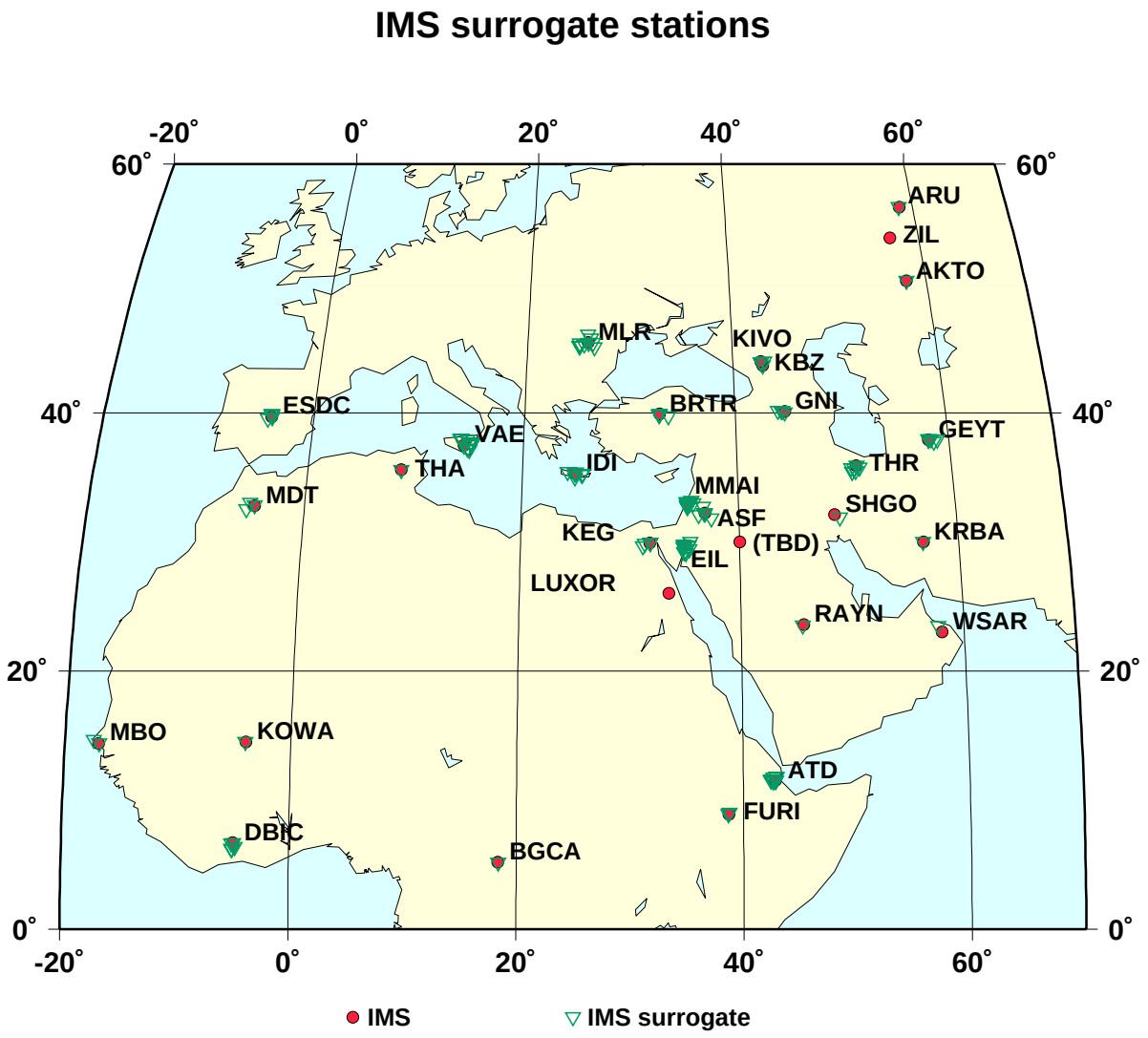

Figure 2. IMS surrogate stations in Group-2 Consortium region of interest

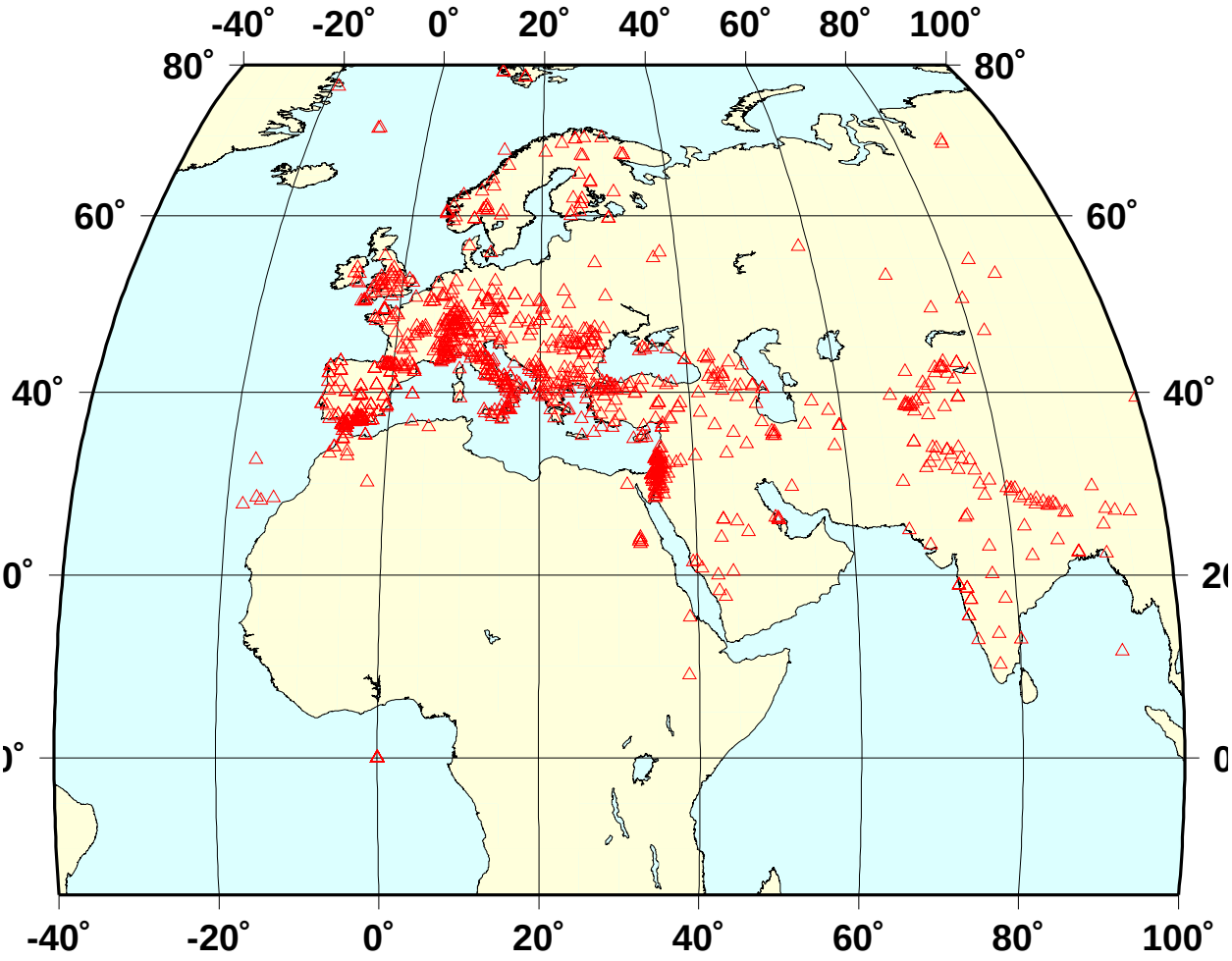

Figure3. Other stations in Group-2 Consortium region of interest that may be used in validation testing.

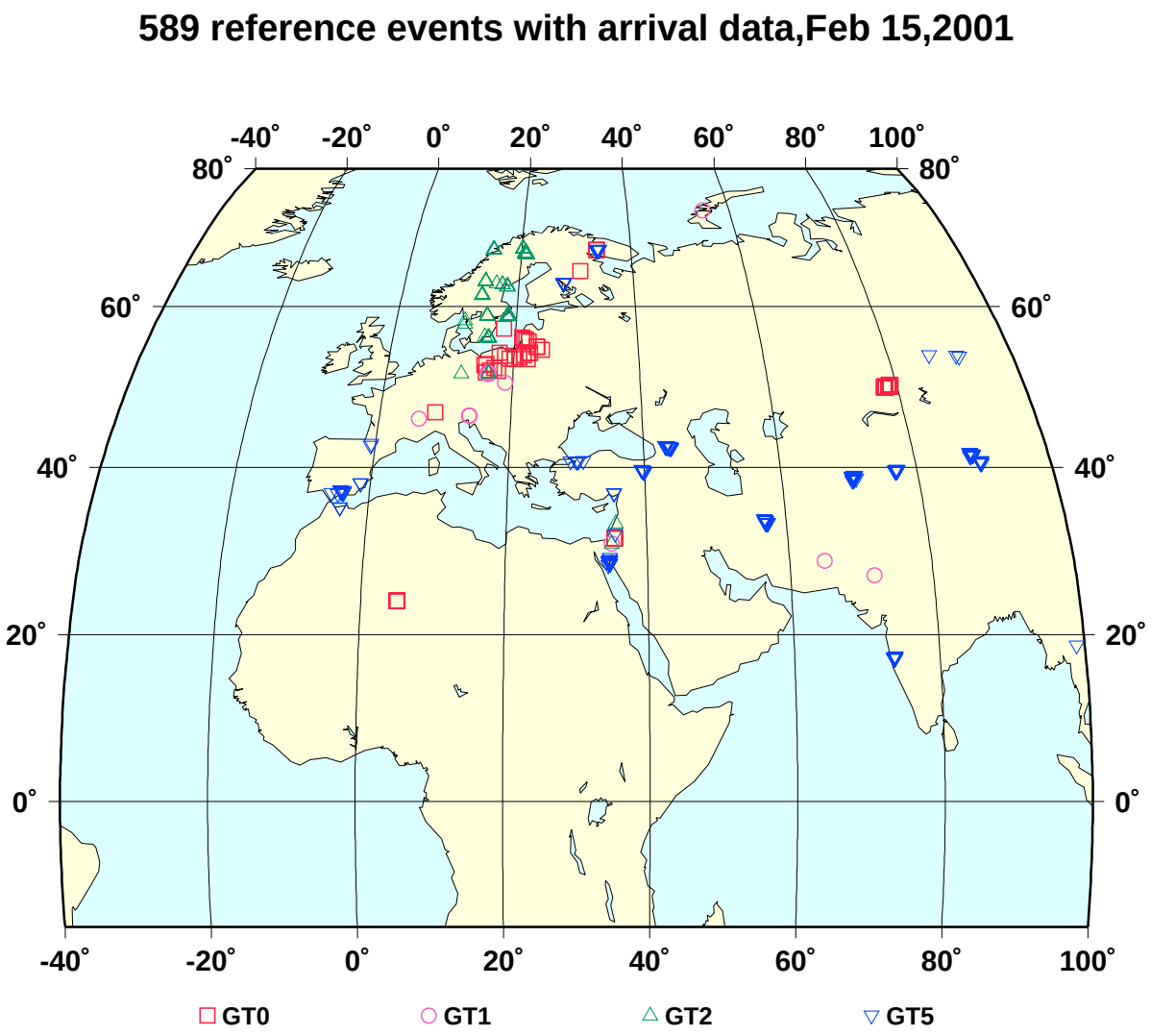

Figure 4. Reference events with arrival data in the Group-2 Consortium database as of February 2001.

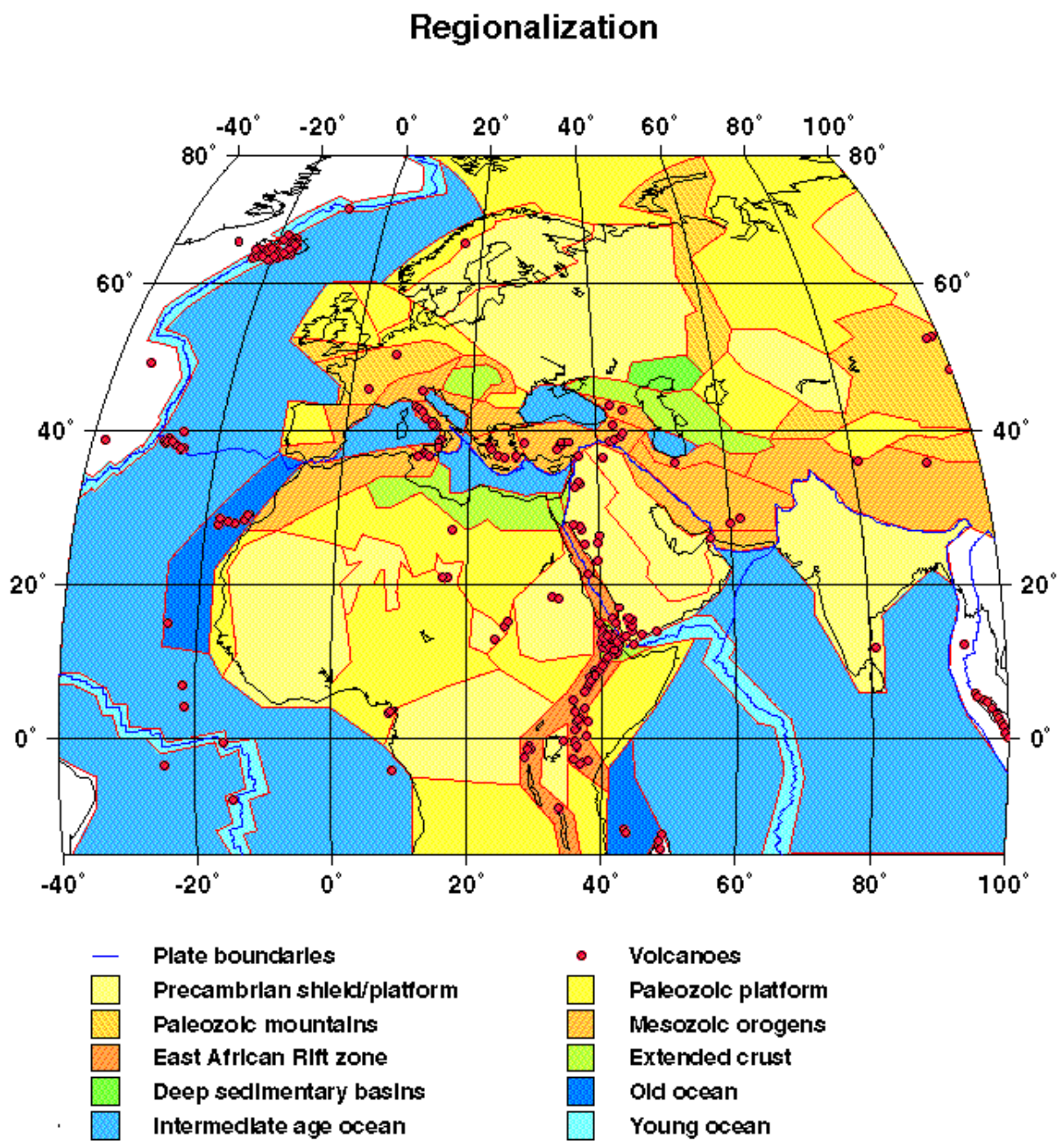

Figure 5. SAIC regionalized model 1.0.

Appendix: Evaluation metrics

1. DISTANCE FROM GT (n=):

total number of solutions: with and without SSSCs: sdev, average deviation, Student t-significance test, median distance with and without spread, percentiles, minimum, maximum, Wilcoxon signed rank test.

% (n=) solutions are closer to GT: with and without SSSCs: sdev, average deviation, Student t-significance test, median distance with and without spread, percentiles, minimum, maximum, Wilcoxon signed rank test.

% (n=) solutions moved away from GT: with and without SSSCs: sdev, average deviation, Student t-significance test, median distance with and without spread, percentiles, minimum, maximum, Wilcoxon signed rank test.

% (n=) solutions are closer to GT by 20%: with and without SSSCs: sdev, average deviation, Student t-significance test, median distance with and without spread, percentiles, minimum, maximum, Wilcoxon signed rank test.

% (n=) solutions moved away from GT by 20%: with and without SSSCs: sdev, average deviation, Student t-significance test, median distance with and without spread, percentiles, minimum, maximum, Wilcoxon signed rank test.

2. DISTANCE FROM GT as a function of ndef:

Same metrics as in 1.

3. AREA OF ERROR ELLIPSES (n=):

total number of solutions: with and without SSSCs: sdev, average deviation, Student t-significance test, median distance with and without spread, percentiles, minimum, maximum, Wilcoxon signed rank test.

% (n=) ellipses are smaller: with and without SSSCs: sdev, average deviation, Student t-significance test, median distance with and without spread, percentiles, minimum, maximum, Wilcoxon signed rank test.

% (n=) ellipses are larger: with and without SSSCs: sdev, average deviation, Student t-significance test, median distance with and without spread, percentiles, minimum, maximum, Wilcoxon signed rank test.

% (n=) ellipses are smaller by 20%: with and without SSSCs: sdev, average deviation, Student t-significance test, median distance with and without spread, percentiles, minimum, maximum, Wilcoxon signed rank test.

% (n=) ellipses are larger by 20%: with and without SSSCs: sdev, average deviation, Student t-significance test, median distance with and without spread, percentiles, minimum, maximum, Wilcoxon signed rank test.

4. ELLIPSE COVERAGE

90% ERROR ELLIPSE COVERAGE W/O SSSCs

GT error=0 GT error=5

in % out % in % out % total

90% ERROR ELLIPSE COVERAGE WITH SSSCs

GT error=0 GT error=5

in % out % in % out % total

5. ORIGIN TIME DIFFERENCE FROM GT (n=):

Same metrics as in 1.

5. ORIGIN TIME ERROR (n=):

Same metrics as in 1.

6. STANDARD DEVIATION OF OBSERVATIONS (n=):

Same metrics as in 1.

7. TIME RESIDUAL, DEFINING PHASES (n=):

total number of solutions: with and without SSSCs: sdev, average deviation, Student t-significance test, median distance with and without spread, percentiles, minimum, maximum, Wilcoxon signed rank test.

% (n=) time residuals are smaller: with and without SSSCs: sdev, average deviation, Student t-significance test, median distance with and without spread, percentiles, minimum, maximum, Wilcoxon signed rank test.

% (n=) time residuals are larger: with and without SSSCs: sdev, average deviation, Student t-significance test, median distance with and without spread, percentiles, minimum, maximum, Wilcoxon signed rank test.

% (n=) time residuals are smaller by 20%: with and without SSSCs: sdev, average deviation, Student t-significance test, median distance with and without spread, percentiles, minimum, maximum, Wilcoxon signed rank test.

% (n=) time residuals are larger by 20%: with and without SSSCs: sdev, average deviation, Student t-significance test, median distance with and without spread, percentiles, minimum, maximum, Wilcoxon signed rank test.

8. TIME RESIDUAL, ALL PHASES (n=):

Same metrics as in 7.